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(56) Documents Cited
GB 2230091 A GB 2165356 A GB 2107462 A
GB 2012422 A US 4800981 A

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(54) **Seismic detector**

(57) A seismic detector, for detecting underground activity, has a pressure-resistant housing 2 containing four or more directional sensors 4, 5, 6, 7, stacked vertically above each other, preferably oriented such that they point in directions originating from the centre of an equi-lateral tetrahedron, one to each corner. Means 12 are provided for electronic amplification of the signals received by the sensors 4 - 7 and the sensors are preferably accelerometers.

FIG. 1

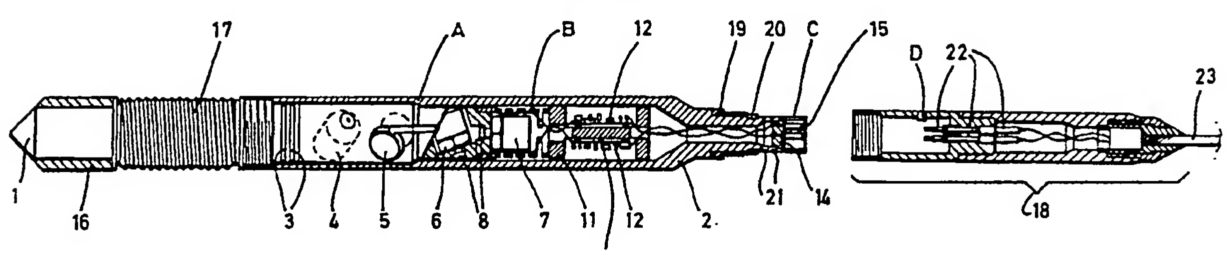

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FIG. 1

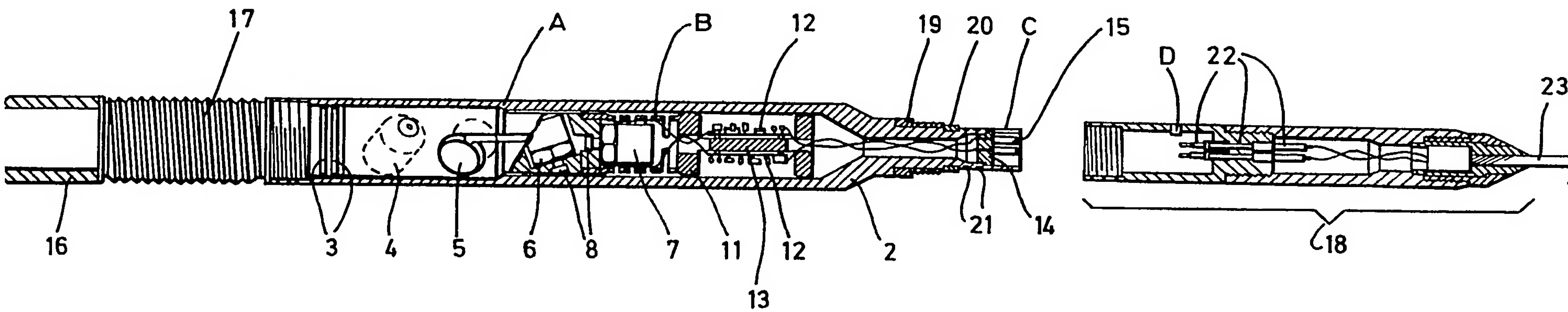


FIG. 2

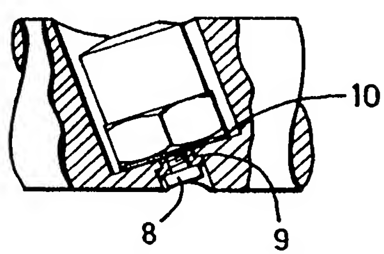


FIG. 3

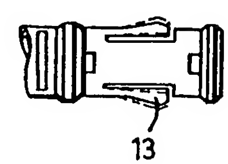
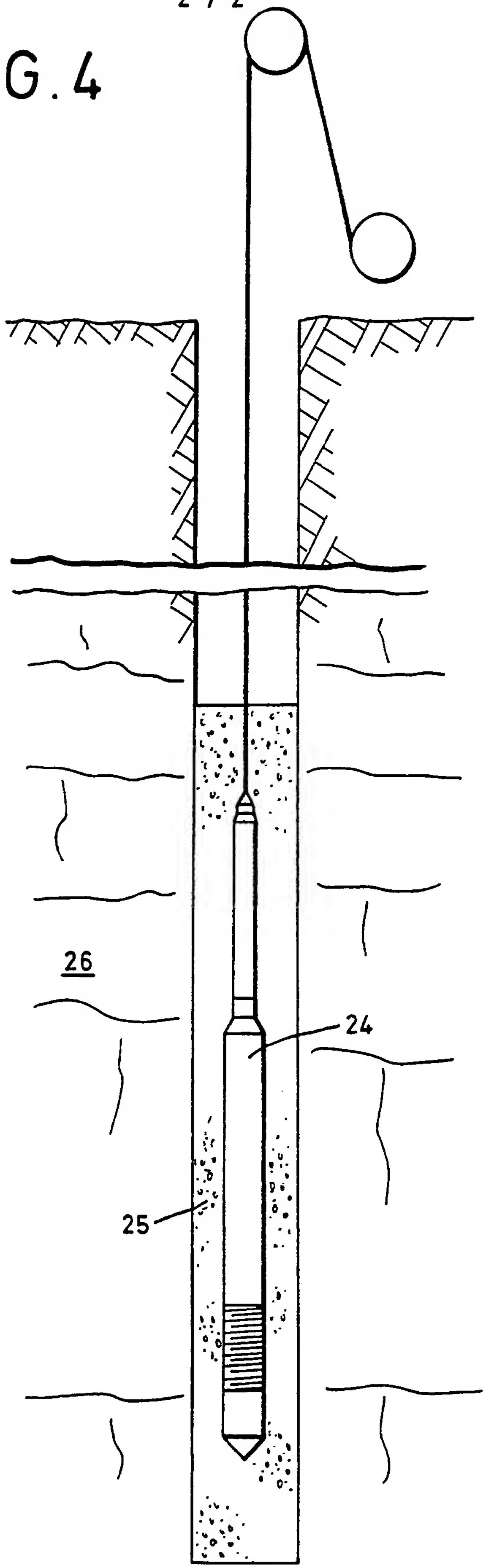


FIG. 4



Improvements in or Relating to Seismic Detectors

This invention relates to seismic devices of the type which are lowered down bore-holes to detect and measure seismic activity as represented by particle velocity or particle acceleration.

It is already known to use, for such purposes, seismic detectors which have sensors oriented along three axes preferably at right angles to one another.

However, in such a detector, using three axial sensors, if one sensor (or the electronics associated with it) should fail, then the resulting two-component detector cannot give a representation of the three-dimensional movement which it is attempting to measure. Only a two-dimensional projection of this three-dimensional motion onto a plane can then be measured.

Also the margin of error in such a three-axis detector is considerable since the 'error inflation factor' (i.e. the relationship between the error propagated from the measurement to the final estimate) is substantially 1 for each axis of a three-component system which means that for such a system the errors are compounded in the final estimates.

We have now discovered that the efficiency of such detectors can be considerably enhanced by means of adopting the configuration according to the present invention, which is defined below.

According to this invention a seismic detector for detecting underground activity comprises a pressure-resistant housing containing four or more directional sensors and means for electronic signal amplification. Preferably these sensors are oriented in an equi-angular configuration, with respect to one another.

The preferred arrangement has four directional sensors oriented in a tetrahedral configuration, with equal angles between them i.e. they point in directions originating from the centre of an equilateral tetrahedron, one to each corner.

Preferably the sensors are stacked vertically above each other in the housing.

If the sensors are so arranged, even if one fails then a three-dimensional particle motion can still be followed. There will be some loss of accuracy, as less measurements are being made but a three-dimensional movement can be followed.

For a tetrahedral configuration, using four sensors, even if one sensor fails, the measuring ability is only degraded to, at worst, 57% of that of a conventional three-component detector and on average only to 82% of a conventional 3-component detector, which would still be acceptable.

As an estimate of the gain in reliability consider the following example. Assume that over a given time period there is a 1% probability of a sensor and/or its associated electronics failing. Then over the same time period it is about eight times less likely that two sensors will fail in a given four component tool. Two sensors need to fail before the tool stops giving three dimensional data. Thus for this time period, assuming failures are independent, a four component tool is eight times more reliable than a three component tool. Obviously in the event of a total failure of some common element of the tool the number of axes is irrelevant.

It is possible to visualise a detector with 5 or 6 directional sensors but in general these are less practical than the 4-component system since in the case of the 5-component system it is not equi-angular and does not provide a full two-component failure redundancy. Also the more sensors which are added the greater becomes the size and engineering complexity of the tool, which could affect resonances etc. The six component system has the disadvantage of not having full two-component redundancy. If any two co-linear sensors should fail then it would behave effectively as a two-component tool. There would be a 20% chance of the sensors failing in this way. The criticism that to achieve a full two-sensor redundancy means adopting a non-optimum sensor configuration appears to hold for the six-component case.

Tools where replacement is costly or time-consuming or where the data is likely to be unique and either expensive or impossible to reproduce will be considerably more durable where a tetrahedral arrangement of four sensors is used in place of the conventional three sensors oriented at right-angles to each other.

Thus in summary, the use of four sensors in a seismic detector has considerable advantages over the use of three sensors, the two main advantages being as follows:

1. Four sensors means that four measurements are now being made on three unknowns, thus some form of error determination can be made. This is not the case with three sensors.

2. Four sensors means that there is some redundancy in the system. Thus, if the four sensors are suitably arranged then even if one of them fails, the sonde can still make useful measurements and the particle motion can still be reconstructed. This is not the case with three sensors.

A particular embodiment of the invention will now be described by reference to the accompanying drawing, which show the main elements of a detector according to the invention.

With reference to the drawings,

FIGURE 1 shows the principal elements of a detector or sonde according to the invention;

FIGURE 2 shows a detail of the mounting of one of the sensors (accelerometer) within the sonde;

FIGURE 3 a detail of the electronic chassis of the sonde, and

FIGURE 4 a general view of the sonde as inserted into a bore-hole.

With reference first to Figures 1 and 2 the detector or sonde consists of two main mechanical components, the chassis weight (1) and the pressure-housing (2). Components (1) and (2) screw together and are sealed at their connection by a pair of O-rings (3).

Rigidly connected to the chassis 1 are four sensors (accelerometers (4, 5, 6 and 7) each of which is held in place by a cap-head screw (8) (Figure 2) which is electrically-insulated from the chassis (1) by an insulating sleeve (9). Each sensor is insulated from the chassis (1) by a thin insulating disc (10). In this way the sensors (4, 5, 6 and 7) are fully insulated from the sonde body assembly (1 and 2). The sensors are oriented in equi-angular tetrahedral configuration.

To eliminate any free resonance of the internal section of the chassis (1) an interference fit is achieved between the chassis (1) and the pressure housing (2) at point A.

Mounted within the pressure housing (2) at the end of the chassis remote from the weight (1) is the electronics chassis (11). This chassis (11) incorporates a flexible section B which isolates any resonance associated with the electronics assembly (12). The chassis (11) also incorporates leaf-spring dampers (13) (Figure 3) to further reduce any resonance effects.

Electrical signals from the sensors (4-7) are processed by the electronics system (12), the output from which is connected to an eight-pin connector bulkhead (14) which has 8 connectors (15) located and sealed within it. This bulkhead (14) is also sealed. On assembly the sonde is filled with dry air through the top of the pressure-housing (2) and the bulkhead (14) is inserted, thus sealing the detector's internal cavity. Located at the lower end of the chassis-weight (1) is an anode (16) which is intended to protect the sonde materials from galvanic corrosion. The thread (17) on the external surface of the chassis-weight produces an extended surface area, further assisting galvanic corrosion protection of the chassis-weight.

For deployment, the sonde is connected to a custom cable-head (18) which connects the sonde to an oil field standard 7-conductor wire line logging cable (23).

A threaded ring (19) on the outside of the pressure-housing (2) is retained by a load-bearing split-ring (20). As the cable-head is mated with the pressure-housing, keyway (C) engages with key (D) in the cable-head and thus the sonde and cable-head are mechanically connected by the threaded ring (19). Seals (21) on the sonde seal the connection. The electrical connection is formed from connectors (15) a the sealed connector assembly (22) which, in turn, is connected to the logging cable (23) and thus to surface.

With reference to Figure 4, the sonde (24) is lowered into a cement-filled bore-hole (25) the cement, on setting, preventing any structural resonance and holding the sonde within the surrounding rock-mass (26).

CLAIMS

1. A seismic detector, for the detection of underground activity, comprising a pressure-resistant housing, containing four or more directional sensors and means for the electronic amplification of signals received by said sensors.

2. A seismic detector, as claimed in claim 1, in which four sensors are used.

3. A seismic detector, as claimed in claims 1 or 2, in which the sensors are arranged in an equi-angular configuration with respect to one another.

4. A seismic detector, as claimed in claim 3, wherein 4 sensors are arranged in a tetrahedral configuration, with equal angles between them.

5. A seismic detector, as claimed in any preceding claim in which the sensors are stacked vertically above each other in the housing.

6. A seismic detector substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

Amendments to the claims have been filed as follows

CLAIMS

1. A seismic detector, for detection of underground activity, comprising a pressure - resistant housing containing four directional sensors, which are arranged in substantially equi-angular configuration with respect to one another, and means for the electronic amplification of signals received by the said sensors.

2. A detector as claimed in claim 1 wherein the 4 sensors are arranged in a substantially tetrahedral configuration (as hereinbefore defined) with respect to one another.

3. A detector as claimed in claims 1 or 2 wherein the sensors are stacked vertically above each other in the housing.

4. A seismic detector substantially as described with reference to Figure 1 of the accompanying drawings.

Patents Act 1977

Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition L) G1G (GEEA; GMB)

(ii) Int Cl (Edition 5) G01V (1/40, 1/20, 1/16)

Search Examiner: VICKI STRACHAN

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search: 22 APRIL 1993

Documents considered relevant following a search in respect of claims 1-6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2230091 A (THE SECRETARY OF STATE FOR ENERGY) See page 10, lines 33-35	1, 2, 3
X	GB 2165356 A (AMOCO) See Figure 1	1, 3, 5
X	GB 2107462 A (SOCIETE NATIONALE ELF AQUITAINE) See Figure 1	1, 3, 5
X	GB 2012422 A (SCHLUMBERGER LTD) See Figure 1	1, 2, 3, 5
X	US 4800981 (UTTECHT ET AL) See Figure 2	1, 3

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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